IN THE SPECIFICATION

Amend the title of the invention to "TRANSONIC HULL AND HYDROFIELD, MULTIHULL AND ASSOCIATED CONTROL SURFACES"

On pg. 73 of the specifications, after line 22 and before line 23, insert the following description of Figs. 48 and 49:

Rapid motion of control surfaces on the stern of a high-speed boat

The load on tabs on the stern of a powerboat, for example, those on Fig. 14d, and Fig. 16, or those shown in the "Owner's Manual of Bennett Trim Tabs", can be very high, and may become critical at high speed for tabs having adjustable angles. Indeed, the loads can be unmanageable under manual controls, and even under hydraulic controls at high speeds. Hence, currently trim tabs at the stern of high speed boats have pre-set angles, have small areas, are not continuous across the stern, and if adjustable in angle at high boat speeds, move with hydraulic power with very slow motions, not suitable for rapid angle changes at high boat speeds. It is not feasible to use state of the art tabs for rapid continuous change of angle in response to individual wave encounter, such as angular motion of a trailing surface on a per wave frequency encountered at high boat speed. To illustrate the problem, a "fast" action of a "state-of-the-art" right and left trim tab for a powerboat is 9-10 seconds per cycle under hydraulic power with hydraulic pressure of 1800 PSI (Bennet Trim Tabs, Owner's Manual, pg. 5). Obviously this is inadequate for a high frequency of wave encounter, which could be as adverse as 1 wave per second, or even less, depending on wavelength caused by a sea state, and boat speed.

The design for rapidly movable control surface at the stern of a high-speed boat, has serious problems:

The hydrodynamic pressures on these surfaces can be enormous. For example at 70 knots, the remote dynamic pressure related to structural and control design of a trailing surface is 4900 lb/sq. ft., and at 100 knots 10,000lb/sq. ft. On a 10 ft. beam, a flap or aileron type surface with a 1 ft. chord would have an area of 10 ft/sq and would develop forces, which are dependent on local

angle of attack of the flap. Under "slam" conditions loads could reach very high values that are a function of the slam angles related to dynamic pressures already cited as high as 49000 lb and 100,000 lbs. per square feet.

Aerodynamically balanced control surfaces for aircraft are not a reasonable approach for naval application, as they have never operated to such high values of dynamic pressure. For example at 400 knots the remote aerodynamic pressure q is only 544 lb/sq. ft., and that already requires sophisticated hydraulic actuation for rapid motions of a flap-type aileron. But the same remote pressure, 544 lb/ft^2, can be reached by water at only 13.80 knots!

Moreover, the airflow around aerodynamically balanced flaps, or balanced ailerons of aircraft, covers both lower and upper surfaces of the device. In contrast, the use of a flap or aileron type device at the stern of a planning boat has variable high hydrodynamic loads only on the lower face of the device, which is developed by its contact with a high-density fluid field at high speed. But the top face of such a device has a constant atmospheric static pressure of a very light density fluid, air. This renders all aerodynamic data of flaps or ailerons for aircraft, which necessarily has the same density of fluid flow on its upper and lower surfaces of a flap, inapplicable to naval stern flaps or ailerons mounted on the rear end of the lower surface of a vessel.

Moreover, there is an enormous difference in the density of water and air, water being approximately 840 times heavier, rendering aircraft experience not applicable.

From the above remarks, it is evident that the loads (lb), pressures (PSI), and hinge moments (lb. inch) of a movable controllable flap or aileron type surface for naval applications can be enormous, are not predictable from existing data, and indeed are unmanageable, especially if a frequent motion of a flap is desired for pitch control purpose. In this respect, it is pertinent to clarify the distinction between a tab and a flap, or aileron type flap. The former does not require rapid angular motion and/or low loads in aircraft or boats. The latter in aircraft must have capabilities of fast and/or continuous motion for pitch control and similar aircraft applications, but so far is not feasible at the stern of a fast boat.

Notwithstanding all the difficulties reviewed above, this writer has discovered, investigated

by theoretical analysis, and verified by designs which are proven by experimental tests, that it is feasible to move a large surface at the rear end of a vessel with small loads and small hinge moments at a high frequency, nevertheless capable of causing powerful rapid changes of pitch angles of the vessel supporting the flap. To achieve this objective, a second trailing surface is mounted on the first surface, with highly specific relation of angular motion as is described in Figs. 48 and 49.

Specifically, Fig. 48 shows the stern of a boat 441 having an athwarship lower border 442 defined in the drawing by structural angle 443 secured to stern 440. The lower surface of angle 443 is coplanar and forms part of the lower surface of boat 441. On border 442 there is mounted a first movable surface element 443 articulated at its forward edge at a hinge along border 442. For observation of water flow below surface 443, there are circular inserts at 444 and 445 of transparent material, which permits vision because when boat 441 is at high speed, there is only air above surface 443.

At the rearward edge 446 of first surface 443 there is articulated a second movable surface 447 hinged at its upstream edge at 446. Angular motion of first surface 443 about hinge at 442 is opposite to angular motion of surface 447 about its hinge at 446, as is seen in greater detail in Fig. 49. The angular motion of first surface relative to boat 44_ is caused by push pull action of link 448 causing, through lever 449, the push pull action of level 450 which in turn acts on horn or protrusion 451 on first surface 443, causing its angular motion.

The appropriate opposite angular motion of surface 447 is caused by link 452 connected at its forward end 453 to part of stern 440 at location 443, and at its rear end to horn or protrusion 454, which is secured on the upper face of second surface 447.

The height of link 452 above articulation at 446 is approximately the same as that of 452 above articulation at 442. However, location of 453 is somewhat upstream of border 442. Upward angular motion of 443 relative to boat 441 raises 446 above its neutral position shown as 457 in Fig. 49a. This causes, by mechanico-kinematic action of link 452 hinged to boat 441 at 453 as shown in Fig. 48, opposite angular motion of second surface 447 relative to surface 443, as shown in more detail of Fig. 49.

The critical effect of opposite angular motion of surface 447 relative to surface 443 on the magnitude of push pull forces 455 required to move first surface 443 is exemplified on Fig. 49. Specifically Fig. 49 shows in its detail (a) a side view of Fig. 48 establishing the angular deflection sign convention, which specifies the angle of the trailing or second surface 447 relative to the first surface 443, and the angle of 443 relative to the bottom surface 450 of boat 441.

The neutral position corresponds to δ f and δ t = 0 degrees, both parallel and coplanar with bottom surface 456 of boat 441.

An example of the important relation between δ f and δ t which decreases magnitude of control force ± F symbolized at 455, is shown as part of detail (a) of Fig. 49, namely

$$\delta t / \delta f \quad = \quad -9.5/8$$

$$\delta t / \delta f \quad = \quad +9.5/-8$$

Variations of these ratios are possible, depending on the ratios of chordwise length of second and first surface element, which is approximately 0.20 in Fig. 49. The critical, crucial, and unique effect of these ratios is better understood with its test results.

Comparing detail (b) of Fig. 49 showing a conventional tab at a negative angle, to detail (c) showing this writer's unique design, both tested at 38 MPH and at -4°, shows that the control force at 455 drops from 9.5 lbs to about 0.43lb. This is a decrease of 95%. The actual force at link 450 is 6 times larger at 38MPH, by reason of arm ratio of lever 449.

Comparing detail (d) showing a conventional tab at a positive angle, to detail (e) showing this writer's unique design, both at 38 MPH and +4°, shows that control force at 453 drops from 16 lbs to 2.5 lbs, a decrease of 84.4%. The actual force at link 450 is 6 times larger at 38 MPH, and would be 6 x 4 = 24 times larger at 76 MPH, and 48 times for two small flaps. Doubling the flap size would raise the load 4 x 48 = 192 times!

These results show that reducing the loads by 84% has a unique value in that, for the first time in naval technology, a movable trailing surface rather than a fixed or slow moving tab, can be operated at much higher speeds than before, with greater area if so desired, and with this writer's discovery and invention at a fast angular rate, which for the first time permits a design a pitch control

system for pitch stabilization on a per wave basis at high speed, a most important accomplishment for safety and comfort of fast boats and fast ships.